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THE HESSIAN FLY IN WEST VIRGINIA AND HOW TO PREVENT LOSSES FROM ITS RAVAGES.

BY A. D. HOPKINS, PH. D.

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THE HESSIAN FLY IN WEST VIRGINIA AND HOW TO PREVENT LOSSES FROM ITS RAVAGES.

By A. D. Hopkins, Ph. D.

The great loss to farmers in West Virginia during the last few years from the ravages of the Hessian Fly on wheat, has led to a general desire, among those who contemplate sowing wheat this fall, for information on best methods of preventing or mitigating losses from the same source in the future.

The object of this bulletin is to contribute the desired information by presenting a brief summary of the principal results of investigations by other entomologists, and the experience of successful wheat growers, together with some additional matter from the results of original investigations by the author, relating especially to proper dates for sowing wheat at different latitudes and altitudes to avoid attack by the fly in the fall.

The bulletin is intended to be of immediate practical use to the wheat growers of the State; therefore all technical details and general discussions are eliminated, as far as practicable, and to those few of our readers who may desire more detailed information, we will refer them to two of the principal recent publications on the subject, which together give a complete up-to-date history and account of the known facts relating to the insect and methods of combatting it. The publications are as follows: The Hessian Fly in the United States, By Professor Herbert Osborn, Bulletin No. 16, New Series, U. S. Department of Agriculture, Division of Entomology, 1898. This is a pamphlet of fifty-seven pages, illustrated by three plates and eight figures, and in addition to the general matter of great interest, it contains reference to 141 of the principal

publications relating to the Hessian Fly issued between 1797 and 1893. The other is Bulletin No. 107, of the Ohio Agricultural Experiment Station, May, 1899. This is by one of the best authorities on the subject, Professor F. M. Webster, who as entomologist both of the Ohio and Indiana Experiment Stations, has devoted many years to the study of this insect and to experiments to determine the proper dates to sow wheat at different latitudes.

SUMMARY OF FACTS RELATING TO THE INSECTS.

How the Fly Lives and Works.—The Hessian Fly is a small, dark colored, two winged fly or gnat, about one-eighth of an inch long, very delicate and scarce visable when in flight. It appears on the wing in May and June, when the female deposits her eggs on the upper surface of the leaves near the stem. The young maggot hatching from these eggs make their way to the outside of the straw beneath the leaf sheath to or near one of the lower joints where they become embedded in the soft part of the stem. Here they remain feeding on the sap and juices of the plant until they are fully mature, when they change to a form resembling a flax seed, which is known as the flaxseed stage. They usually remain in this stage in the straw and stubble until September or October when the adults or flies emerge at dates varying with the latitude and altitude to deposit eggs on volunteer or early sown wheat, rye or barley, where they go through their transformation to the flaxseed stage in which they pass the winter at the base of the growing wheat, to emerge the next spring and repeat the process. The effect on wheat by the spring brood is to cause imperfect developement of the straw and grain, and so weaken the straw at the joints that it falls in all directions as if beaten down by storm. The effect on the wheat in the fall is to cause it to have a stunted growth, dark green or brownish color, and either dies or is prevented from developing grain in the spring.

Broods.—In West Virginia there are two distinct broods: the swarms of one appearing in the spring and that of the other in

the fall. The period of greatest abundance of both swarms vary with the latitude and altitude.

How the Spring and Fall Swarms are Influenced by Difference in Latitude.—Probably the most important results in recent investigations and experiments relating to the Hessian Fly are those obtained by Professor Webster and verified by many successful wheat growers in Indiana and Ohio. Professor Webster concludes, as set forth in his Bulletin No. 107, of the Ohio Station, that there is a rate of difference in dates of appearance and normal periods of depositing eggs due to difference in latitude, and that for the States of Indiana and Ohio the difference in appearance of the swarms, between the northern and southern borders of the States mentioned is about one month. Thus, he was enabled to indicate on a map of Ohio the approximate dates, for each ½ degree of latitude, when it would be safe to sow wheat to avoid the danger period of the fall swarm of the fly.

Dates Based on Latitudes alone of Little or no Value in West Virginia.—While this rate of difference of the danger period of the fly is of great value in indicating dates in level regions like that included within the borders of the States mentioned, they are applicable to only a small portion of West Virginia, owing to the great and varied difference in elevations on the same parallels of latitude.

The Factor of Altitude not heretofore Considered.—So far as the writer is able to determine from available data, the influence of altitude on the habits of the fly, has never been taken into consideration in any discussion of the important problem of normal dates for the ending of the egg depositing period in the fall.

Difference in Altitude more Important than Latitude in West Virginia.—Extended investigations by the writer, in West Virginia, to determine the influence of latitude and elevation on the normal flowering and ripening periods of plants and their fruits, and the periodical appearance and flight of insects, led to the

conclusion in 1897,* that there is often a greater difference between normal dates of such phenomena between the valleys and mountain plateaus on the same parallel of latitude than is found between the extreme southern and northern borders of the State. Indeed the results indicated that as much difference may be found in a single county (Pendleton) as normally at a uniform altitude of 1000 feet in 8 or 9 degrees of latitude. Therefore so far as a large part of West Virginia is concerned, altitude is a far more important factor to be considered than latitude alone.

A LAW OF DEFINITE NORMAL RATE OF DIFFERENCE IN THE PERIODICAL PHENOMENA OF PLANTS AND ANIMALS.

While it is well known that there is a marked difference in the flowering periods of plants, the annual appearance of certain insects and the periodical phenomena of life in general between northern and southern localities, and between valleys and mountains, little progress seems to have been made towards determining the corresponding actual rate of difference in time, with difference in latitude and altitude.

The Results of Original Investigations by the Writer indicate:

First, that, under similar conditions of land surface other than altitude, there is a definite normal rate of difference of time in the periodical phenomena of plants and animals for all difference in latitude and altitude.

Second, that, under normal conditions, the rate of average difference in the dates of the beginning or ending of such phenomena is not far from one day for each fifteen minutes ($\frac{1}{4}$ degree) of latitude and one day for each one hundred feet of altitude.

Third, that the dates of commencing or ending of a given period vary with the season, the weather and local physical conditions, such as exposure and character of soil, but that the rate of difference under each condition is the same.

* As indicated in Bulletin 50, W. Va. Agr. Exp. Sta., p. 17, and Pro. Asso. Econ. Entomologists, Bull. 17, New Series, U. S. Dept. Agr. Div. Ento. pp. 48-49.

The Results of our Investigations also indicate:

First, that from a series of observations and records, the average, or normal dates, of any well marked period may be determined for any latitude or altitude, and in the same manner variations in dates, (due to seasons and local conditions) may be corrected for each season and for all well marked differences in local conditions.

Second, that, knowing the normal dates for a given phenomenon in a given locality within the area of a state or small country, the determination of the normal dates for the same phenomenon under similar conditions in any or all other localities within the same area is a simple mathematical problem, to be solved, as in the case of the fall swarm of the Hessian Fly, by the following rule:

RULE FOR THE APPROXIMATE DETERMINATION OF NORMAL DATES FOR THE ENDING OF THE FALL SWARM OF THE HESSIAN FLY IN ANY LOCALITY IN THE STATE.

Take a known normal date of a place, of known latitude and altitude, correct this date to a corresponding date at sea level, by adding one day for each hundred feet of altitude above sea level: then for any place north of this sea level base subtract one day for each one-fourth degree of latitude and one day for each one hundred feet of altitude at the place to be determined, and for all points south add one day for each one-fourth degree of latitude and subtract from the result as before, one day for each one hundred feet of altitude. The resulting date will be the approximate normal.

To give an example of this method of determining normals and to demonstrate its value we will take, as the most important and reliable data, the results obtained by Professor Webster, by actual experiments and observations, at Columbus and Wooster, Ohio.* He found that the normal date for the ending of the fall period of active flight or swarming of the fly at Columbus, latitude 40 degrees, was September 25th, and that

* Bulletin 107 (previously cited) page 275.

the corresponding date for Wooster, latitude 40 degrees and 49 minutes, was September 20th, which he states agrees almost exactly with results obtained in Indiana, and formed the base for conclusions, as set forth in his Bulletin No. 107.

Now, to take Columbus, latitude 40 degrees and altitude 800 feet above tide, with normal date of September 25th, and correct this date to a corresponding one at sea level, by adding eight days (one day for each 100 feet above sea level) we have October 3rd at latitude 40 degrees, as the determined sea level base from which to make calculations for Ohio and West Virginia. Now, we will take as an example Wooster, Ohio, laititude 40 degrees, 49 minutes, altitude 1,000 feet, and calculate the normal for that place, as follwos: the difference in latitude between the two places is 49 minutes, which equals, at the rate of one day for each one-fourth degree of latitude, three and four-tenth days. Leaving off the fractions, and substracting three days from the determined sea level base, October 3rd, we have September 30th or three days difference, at sea level, due to latitude alone. Now since Wooster is 1,000 feet above sea level the fly should disappear ten days earlier, so that by subtracting ten days from September 30th, we have September 20th as the normal date for that place, *which corresponds exactly with the date determined by Professor Webster*

To determine the normal in a like manner for a locality south of the determined sea level base we will take a place (near Pt. Pleasant, West Virginia) located in latitude 38 degrees and 45 minutes and at an altitude 800 feet. The difference in latitude between 40 degrees and 38 degrees and 45 minutes is 1 degree and 15 minutes, which is equal to five days later. Five days added to October 3rd equals October 8th; 800 feet altitude equals eight days later, and eight days from October 8th gives us October 1st as the determined normal for that locality, which would be the approximate normal date for the disappearance of the fall swarm of the fly there, after which it would be best to sow wheat to avoid attack.

NORMAL DATES FOR SOWING WHEAT AT DIFFERENT LATITUDES AND ALTITUDES IN WEST VIRGINIA TO AVOID LOSS FROM THE FLY.

Following the law and rules outlined above, we are enabled to indicate on a map of the State the approximate normal dates at different latitudes and altitudes for the ending of the fall swarm of the fly, and the dates at which it is reasonably safe to sow wheat to prevent loss from its ravages. See map.

The Safe Period for Sowing Wheat.—The time between the two dates given on the map for each parallel of latitude under a given altitude is taken as the normal safe period for sowing wheat in all localities coming near or between the two parallel lines, and within 200 feet more or less of the altitude given, so that in most sections of the State, except where there is a strong contrast of mountains and valleys, the same dates may answer for an entire county, and the period given will provide for difference in local conditions, and give ample time for all seeding to be done by the later dates given.

The dates may vary several days from the given normal in different seasons, and in localities where striking local conditions prevail. Therefore, the dates and periods may be changed as from time to time the prevailing conditions and the experience of the most successful wheat growers may indicate.

A wet August and September, as has been determined by other authors may cause an early disappearance of the fly, while a protracted fall drouth and warm weather may cause a later disappearance.

A light sandy and "warm" soil over a considerable area in one localitty may possibly cause the fly to disappear several days later. A heavy, wet clayey soil may cause, in a like manner, a much earlier disapperance. A north exposure may cause an earlier disappearance, while a south exposure may cause a later disappearance.

Just how much the seasons, weather and local conditions will influence the dates may be best determined from actual observations and experience in each locality. Hence, every wheat grower should keep a careful record of dates of sowing wheat in

his locality and observe results for his future guidance. Remember that *early disappearance due to local conditions is of little importance* to wheat growers unless over a large area, since the fall swarm of the fly may travel or be carried by the wind for considerable distance and may settle and deposit eggs on wheat sown earlier than the normal dates.

Localities where local conditions cause a late disappearance of the fly are of especial importance, since, if wheat is sown in such localities at or near the given normal date serious loss might result from the retarded disappearance of the fly. Therefore, when such retarding inflences are found to prevail wheat should be sown towards or after the later dates indicated on the map for the latitude and altitude of the locaity.

Never sow wheat before the dates given for each latitude and altitude in the vertical column marked o, will doubtless be a safe rule to adopt under all conditions, and if generally followed by all farmers we are confident will be one of the very best methods of preventing future losses from the ravags of the fly.

THE PERIOD FOR SOWING FALL WHEAT TO SECURE THE BEST DEVELOPMENT OF THE PLANT AND YIELD OF GRAIN.

As is well known by all observing and experinced farmers wheat can be sown too early and too late to yield the best results. So that for each locality or section of the State *there is a proper normal period for sowing wheat.*

The normal habit of the wheat plant is governed by the same natural laws as those which govern its enemy, the fly.* Therefore the proper normal period for sowing wheat to secure the best crop will vary with the latitude and altitude in the same or similar proportions as that given for the ending of the fall swarm of the fly. Taking from fifteen to twenty days as the normal length of the best period for sowing fall wheat, and

* That the fly and wheat are governed by the same phenological law is clearly shown by the fact that in regions favorable for the growth of fall wheat only the fly is double brooded, one attacking the wheat in spring and the other attacking it in the fall, and passing the winter in the growing plants, while in regions favorable for the growing of spring wheat alone, there is but one destructive brood of the fly which attacks the growing wheat in the spring, and passes the winter in the stubble.

assuming that for each locality the commencing of this period is about one week earlier than the normal date for the ending of the fall swarm of the fly, and ending one week or ten days after this normal date, the map and table not only indicate the proper time to sow wheat at diffrent latitudes and altitudes to avoid the fly, but the best normal wheat sowing period for each locality, viz: within seven to ten days after the normal date for the disappearance of the fly.

IMPORTANCE OF THE ADOPTION OF A UNIFORM PERIOD FOR SOWING WHEAT.

The writer wishes to emphasize the strong recommendation of Professor Webster for the adoption of a uniform safe period for sowing wheat in each section of the State, as one of the best means of eradicating the fly and preventing losses from its ravages. This is of great importance because,

First, During the fall period of swarming or active flight the fly will find no wheat on which to deposit eggs.

Second, If no eggs are deposited in the fall there can be no swarms of the fly to attack the wheat in the spring.

Third, If part of the fields in the same locality are sown to wheat before the normal dates given, and suffer from the fall brood, the swarms emerging from such fields the following spring will be carried by the wind, or migrate to adjoining late sown fields, and do serious damage. Indeed this is one of the prime causes of damage to late sown wheat by the fly in the spring, and explains why some wheat sown during the safe period last fall was seriously injured last spring.

THE TIME TO ATTACK AND DESTROY AN ENEMY IS WHEN HE IS WEAKENED FROM A STRUGGLE AGAINST A COMBINATION OF OPPOSING FORCES.

Investigations of wheat stuble sent in from many sections of the State show that a very large per cent of the flaxseed stage of the fly has been killed by parasites or died from other causes. Therefore, while the fly occurred last spring in far greater num-

bers than usual, and caused almost a total failure of the crop in many sections, it has suffered a serious loss from the attack of its enemies. Hence in many sections it is in a weakened struggling condition most favorable for the farmer to do his part towards completing the subjugation of the pest by depriving the survivors of their only source of protection through the winter, namely, early sown and volunteer wheat, barley or rye.

GENERAL RECOMMENDATIONS AND SUMMARY.

There are other requisites for best success in growing wheat than the adoption of proper dates and periods for "seeding."—Those of especial importance which have been long established by practical experience of successful wheat growers are: A well drained fertile soil adopted to wheat; early plowing and a thorough preparation of the seed bed, the proper quantity of best seed to the acre drilled in at the proper time are among the prime and most important requisites for best success in growing a profitable crop. The resulting vigorous, healthy growth of the plant and its consequent advantages and power for resisting injury, will enable it to successfully contend with most of the detrimental influences of drouth, winter and fly.

Some of the old and often repeated methods recommended for combatting the fly and preventing losses from its work, may be briefly summarized as follows:

Burning the stubble to destroy the flaxseed stage has been repeatedly recommended by writers for many years, and is valuable if the larger percent of this stage is not (as was the case during the past season) infested with parasites, when more harm than good would doubtless result from this practice. Then, again, owing to the fact that in West Virginia, at least, wheat land is almost invariably sown to grass or clover, which might be seriously injured by the fire. Under other conditions, the practice would be a good one.

Plowing under stubble should be governed by the same precautions as that relating to burning.

Destruction of volunteer wheat is of great importance, especially in fields near by, or to windward of, newly seeded fields, as well as that in early plowed stubble land. All such wheat should be destroyed when practical by plowing under.

The sowing of trap strips of wheat on one side or around the field in time to attract the main swarm, as well as the stragglers, the strip to be plowed under just before the field is regularly seeded, is a method of great value which has been repeatedly recommended by writers for the past century, but for some cause is seldom adopted.

Rotation of crop, if universally adopted, is of considerable value.

FINAL SUMMARY.

Over the greater part of the State, the past wheat harvest (1900) has been one of great loss to farmers, due to the ravages of the Hessian Fly.

The Hessian Fly is a small dark colored insect resembling somewhat a small mosquito. There are two destructive broods one appearing in the spring and working at or near the lower joints of the wheat, causing the stems to break down in all directions, a condition commonly designated as "straw fallen grain."

The flaxseed, or *dormant stage* of the insect remains in the stubble, until fall, embedded in the outer surface of the straw at or near the joints beneath and protected by the leaf sheath.

The fall brood of the adult fly emerges from the flaxseed stage and the period of its active flight or swarming varies with the latitude, altitude and seasons. The eggs are deposited at this time on the leaves of volunteer wheat and wheat sown early enough to be up before the end of its period of active flight.

The maggots hatching from the eggs descend beneath the leaf sheaths to the base of the plant where they feed on the juices of the tissue and cause the infested plants to have a stunted, dark green or brown appearance and prevent the infested shoots from producing productive heads next spring.

The insects passes the winter in the flaxseed, or winter dormant

stage, and the adults emerge in the spring at periods varying with the latitude, altitude and season.

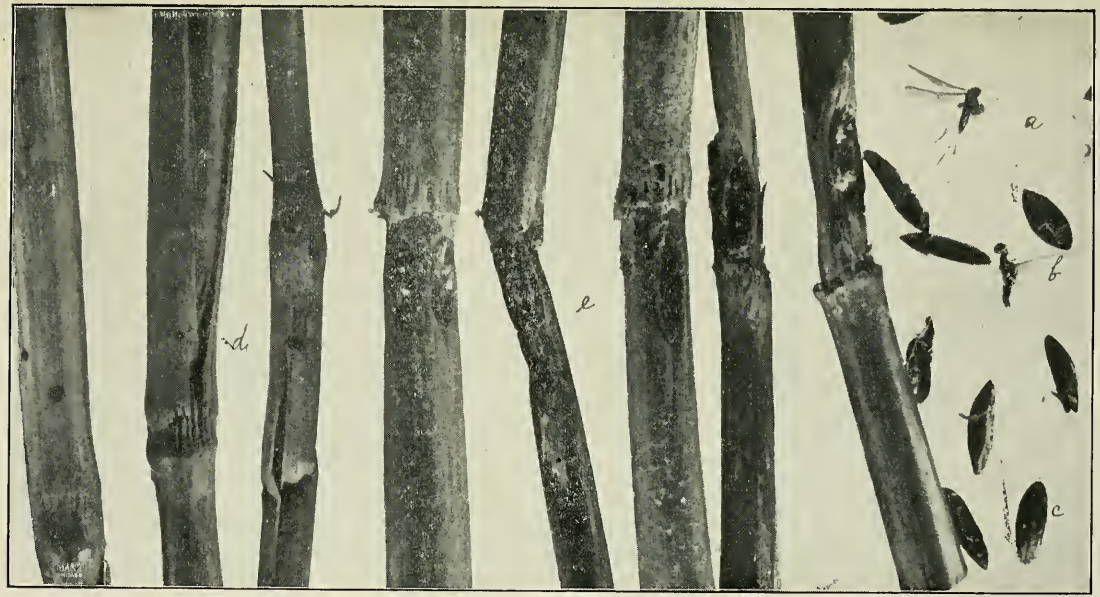
The ending of the fall swarm, or period of active flight, is governed by a natural law, which causes it to vary at the rate of about four days for each degree of latitude (earlier towards the north and later towards the south) and four days earlier for each four hundred feet of altitude above sea level.

According to this law the normol dates, for the ending of the fall swarming period of the fly at different latitudes and elevations in West Virginia, will be near those given in the tables under "normals" and the best period for sowing wheat in each section will be within one week later than the normal indicated for a given latitude and altitude.

Wheat should not be sown earlier than the normal dates given, but may be sown as much later as is in each locality deemed safe to avoid the detrimental influences of fall or spring drouths and winter freezing.

The general adoption of a uniform safe period for sowing wheat in each locality is of the greatest importance.

PLATE I.

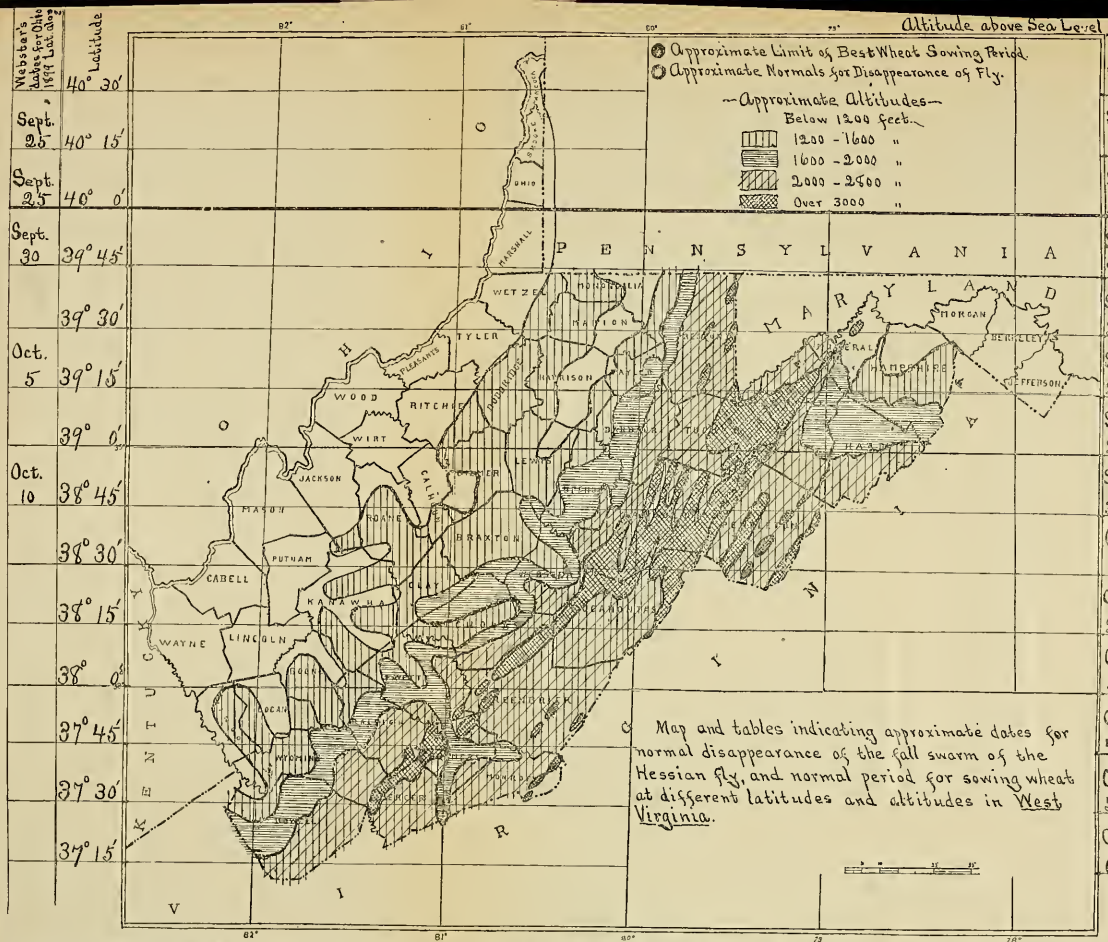


THE HESSIAN FLY.

a, the fly; *b*, the parasite; *c*, flaxseed stage; *d*, *e*, injured wheat straws showing location of flaxseed stage at *e*, and exit holes made by parasites at *d*—all enlarged three times.

THE HESSIAN FLY.

a, the fly; *b*, the parasite; *c*, the flaxseed stage; *d*, *e*, *f*, *g*, pieces of wheat straw showing injury from fly—all natural size.



Latitude	800	1200	1600	2000	2400	2800	3200
40° 30'	September 23, 30	September 19, 26	September 15, 22	September 11, 18	September 7, 14	September 3, 10	Aug. Sept. 30, 6
40° 15'	Sept. Oct. 24, 1	September 20, 27	September 16, 23	September 12, 19	September 6, 15	September 4, 11	Aug. Sept. 31, 7
40° 0'	Sept. Oct. 25, 2	September 21, 28	September 17, 24	September 13, 20	September 9, 16	September 5, 12	September 1, 8
39° 45'	Sept. Oct. 26, 3	September 22, 29	September 18, 25	September 14, 21	September 10, 17	September 6, 13	September 2, 9
39° 30'	Sept. Oct. 27, 4	September 23, 30	September 19, 26	September 15, 22	September 11, 18	September 7, 14	September 3, 10
39° 15'	Sept. Oct. 28, 5	Sept. Oct. 24, 1	September 20, 27	September 16, 23	September 12, 19	September 8, 15	September 4, 11
39° 0'	Sept. Oct. 29, 6	Sept. Oct. 25, 2	September 21, 28	September 17, 24	September 13, 20	September 9, 16	September 5, 12
38° 45'	Sept. Oct. 30, 7	Sept. Oct. 26, 3	September 22, 29	September 18, 25	September 14, 21	September 10, 17	September 6, 13
38° 30'	October 1, 8	Sept. Oct. 27, 4	September 23, 30	September 19, 26	September 15, 22	September 11, 18	September 7, 14
38° 15'	October 2, 9	Sept. Oct. 28, 5	Sept. Oct. 24, 1	September 20, 27	September 16, 23	September 12, 19	September 8, 15
38° 0'	October 3, 10	Sept. Oct. 29, 6	Sept. Oct. 25, 2	September 21, 28	September 17, 24	September 13, 20	September 9, 16
37° 45'	October 4, 11	Sept. Oct. 30, 7	Sept. Oct. 26, 3	September 22, 29	September 18, 25	September 14, 21	September 10, 17
37° 30'	October 5, 12	October 1, 8	Sept. Oct. 27, 4	September 23, 30	September 19, 26	September 15, 22	September 11, 18
37° 15'	October 6, 13	October 2, 9	Sept. Oct. 28, 5	Sept. Oct. 24, 1	September 20, 27	September 16, 23	September 12, 19

EXPLANATION OF MAP AND TABLE.—To ascertain, by means of the map and table, the date for sowing wheat at any given place in the State; find the county on the map and the approximate position of the place in the county—as in the northern, central, or southern portion—then take the parallel of latitude nearest to the place and follow it to the right until it comes to the vertical column for the altitude nearest to that of the average altitude of the locality as indicated on the map. The date to the left in the column will be the approximate normal date for the fly to disappear, and the period between that and the date to the right will be, approximately, the best and safest time to sow wheat in that locality.

CAUTION.

It must be kept in mind that the dates given in this Bulletin, (No. 67) are *normal* dates for *average condition of weather and local influence.* Therefore, a protracted drouth, like that which has prevailed over a large portion of the State this fall, may retard the disappearance of the fly a week or more after the dates given; also that conditions due to local influences may cause, in a like manner, a retarded disappearance in some localities. So that, previous experience in any locality, as of wheat sown later than dates given being injured in the fall, should be a guide for correcting the dates given to a sufficient later safe date for such locality.

NOTICE.

Application for bulletins of this Station should be adressdd to the Director of the West Virginia Agricultural Experiment Station, Morgantown, W. Va.

(The bulletins named below are available for distribution.)

No. 4. The Creamery Industry; Its Adaptability to West Virginia.

No. 5. The Selection of Milch Cows.

No. 6. Six Month's Experience in Running a Creamery, Improved Process of Handling Cream and Churning.

No. 12. The Canada Thistle.

No. 14. Farm and Garden nsects and Experiments with Remedies; Note of the Season.

No. 15. -Raspberry Gouty-Gall Beetle.

No. 16. Yellow Locust, Insect Ravages upon.

No. 17. Black Spruce, Insect Ravages.

No. 19. Your Weeds and Your Neighbor's Part 1. Weeds as Fertilizers.

No. 20. Potato Culture and Fertilization. Tests of Some Varieties of Tomatoes.

No. 21. Injurious Insects and Plant Diseases.

No. 25. Plat Experiments with Commercial Fertilizers on Wheat.

No. 26. Inspection of Commercial Fertilizers.

No. 27. Notes on Pruning.

No. 28. Plat Experiments with Commercial Fertilizers on Corn.

No. 29. Experiments with Potatoes at the Station. Experiments on Corn at the Out-Stations.

No. 30. Address and Notes on Sheep.

No. 33. Sub-rrigation in the Green House.

No. 38. Potato Blight, Potato Scab.

No. 40. Commercial Fertilizers.

No. 42. Vegetables.

No. 43. When, Why, What and How to Spray.

No. 44. Practical Entomology.

Special Bulletin No. 2. Proceedings connected with the celebration upon the completion of the Station Building and the organization of the Sheep breeders and Wool-Growers' Association and the State Horticultural Society.

Third Anunal Report, 1890.

No. 51. Commercial Fertilizers, Jan. '98.

No. 52. Strawberries.

No. 53. Commercial Fertilizers, Dec. '98.

No. 54. Nursery Hints.

No. 55. Sugar Beets.

No. 56. Report on Investigations to Determine the Cause of Unhealthy Conditions of the Spruce and Pine From 1880-1893.

No. 57. Commercial Fertillizers.

No. 58. The Effect of Pressure in the Preservation of Milk.

No. 59. Whole Corn Compared with Corn Meal for Fattening Hogs.

No. 60. Poultry Experiments.

No. 61. Sheep Feeding Experiments.

No. 62. A Study of the Effects of Incandescent Gas-light on Plant Growth.

No. 63. Commercial Fertilizers, 1899.

No. 64. Sugar Beet Investigation in 1899.

No. 65. Commercial Fertilizers.

No. 66. Fruit Diseases and How to Treat Them.